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B70 04007

SUBJECT: Operational Priorities for Skylab In-Flight Experiments - Case 610

DATE: April 6, 1970

FROM: D. J. Belz

ABSTRACT

A system of operational priorities for Skylab experiments is proposed to guide flight planners in choosing among scheduling alternatives commonly encountered in the preparation of crew timelines.

Experiment activities are assigned a quantitative measure of relative operational importance or value. A group of experiment operations can be selected from among candidate groups for a specific location in a timeline by choosing the group with the highest combined value or by maximizing the value of experiments that would be accomplished in the event of an early mission termination.

Assigning numerical values of operational importance to experiments is a subjective process that is properly the function of NASA. Nevertheless, a proposed set of numbers is given to illustrate the system and to provide a starting point from which changes can easily be made.

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MEMORANDUM FOR FILE

1.0 Introduction

From an operational point of view, most experiments in the Skylab Program consist of tasks to be performed by the flight crew. Carefully constructed flight plans are required to assure that all assigned experiments can be completed in an orderly manner on a nominal mission and that the maximum benefit will have been obtained from experiments in the event of an early mission termination.

Opportunities for scheduling a given experiment are usually restricted by requirements peculiar to that experiment and by the availability of crewmen, consumables, or equipment. They are also restricted by numerous mission operating rules derived from system limitations, contingency plans, and managerial judgment.

Within these constraints, however, many scheduling alternatives can be expected to remain. Choices among those alternatives might of course be left to the flight planner's judgment. There is, however, wide agreement within the Skylab Program that operational priorities should be established for experiments, to guide flight planners in making the types of decisions that at present appear arbitrary. It is also widely agreed that such priorities should be established by NASA Headquarters.

During the past two months several priority system concepts have been proposed in varying degrees of detail by members of MLA, MLO and MLS. Each has its apparent advantages and disadvantages. Because the essence of a priority system is subjective judgment, it has been difficult to identify one concept as clearly superior to others. This memorandum presents a conceptual priority system that, if implemented, would enable ML to communicate its judgments on operational experiment priorities to the Centers in a form that will be readily usable by flight planners.

2.0 The Function of Experiment Priorities and Alternative System Concepts

Before any experiment priority system can be devised it is necessary to consider the function it will be expected to perform.

The flight planner, whether working prior to or during an actual mission, is rarely faced with the choice of scheduling one entire experiment or another. Experiments typically consist of a series of crew tasks that can be grouped into convenient "schedulable activities" such as installing a piece of equipment in a scientific airlock or undergoing a specific physiological test. It is from these schedule building-blocks rather than from a list of experiments per se that the flight planner constructs a crew timeline. The function of an operational experiment priority system is therefore to guide a flight planner in weighing the relative merits of scheduling one or more schedulable activities at a particular place in a timeline, as opposed to one or more other activities.

Three general types of priority systems have been discussed recently within ML. These will, for convenience, be referred to here as: (1) rank order lists, (2) exhaustive enumerations, and (3) relative value weightings.

The rank order concept generally involves the listing of experiments or schedulable activities in such a way that relative operational importance can be inferred from position within the list. Each entry in the list is considered to have greater operational value than any other individual entry below it. The limitation of rank order lists is that experiments or schedulable activities can only be considered two at a time, whereas the flight planner often must choose among groups of activities.

The exhaustive enumeration concept requires that all significant alternatives that may confront the flight planner must be identified in advance along with the appropriate decisions. The large number of experiments and the even larger number of schedulable activities in a Skylab mission render it impractical to enumerate all the choices that are likely to be placed before a flight planner in constructing a schedule. It is, however, reasonable to assume that the most important alternatives that may arise in real-time will be thought out in advance and appropriate decisions incorporated in the mission rules.

A priority system based on relative value weightings can avoid the limitations of rank order lists and exhaustive enumerations. Since the concept recommended in this memorandum is of that type, a description of relative-value weighting is deferred to the next section.

3.0 Proposed Operational Experiment Priority System

The relative-value weighting concept defines a quantitative measure of operational importance and assigns a particular value of that measure to each experiment and schedulable activity. The operational importance of a group of schedulable activities is defined as the sum of the individual values of all activities in the group. A group of experiment operations for a specific location in a timeline is to be selected from among candidate groups by choosing the group with the highest combined value or by maximizing the value of experiments that would have been accomplished in the event of an early mission termination. Cost/benefit comparisons among groups of schedulable activities can also be made with numerical values of operational importance defining "benefit" and "cost" measured in man-hours, electrical power required, or some other parameter.

There is obviously no absolute scale on which operational importance can be measured. Fortunately, all that is required is a measure of relative value. In assigning numerical values to the importance of schedulable experiment activities it is therefore possible to choose the total numerical value arbitrarily; for the purposes of this memorandum, the total operational value of all schedulable experiment activities on the three Skylab I manned missions is defined as 100%.

Although the partitioning of that 100% total among individual experiment activities is a purely subjective process, certain subtotals of those numbers should be reasonably related to one another to avoid unintended imbalance among experiments and missions. Subtotals for major categories of experiments on each manned mission are obvious examples. The major objectives of Skylab I are to verify man's capabilities for long-duration flight, to perform extensive solar astronomical observations, and to observe terrestrial targets of scientific or economic importance. Therefore the following categories of experiments are used in this memorandum: (a) medical, (b) ATM, (c) EREP,* and (d) others. The last category includes all experiments not included in preceding categories. Subtotals for all experiments on each manned mission will also be found useful; these "flight totals" define the relative importance of the SL-1/SL-2, SL-3, and SL-4 missions, from the viewpoint of experiment operations.

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*EREP = Earth Resources Experiment Package.

The assignment of individual experiments to particular missions is presently controlled by NASA Headquarters through the Skylab Program Specification. However, not all experiments assigned to missions by that document are appropriate for consideration in an operational priority system designed to guide flight planning. Preflight experiments, post-flight experiments and experiments that do not require in-flight participation by the crew are excluded from consideration in this memorandum.

The grouping of experiment procedures into schedulable activities is presently performed by the NASA Centers, primarily by MSC. It is presumed herein that numerical values of operational importance will be assigned to experiments on each mission by ML and that those values will be partitioned among schedulable activities by MSC. It will therefore be important for ML to review its assignments in the light of MSC's subsequent partitioning to avoid inadvertent distortions of its intent at the level of schedulable activities.

The assignment of specific numerical values to experiments is properly the function of NASA. However, to illustrate the priority system under discussion and to provide a base from which changes can be made, a proposed initial set of numerical values is shown in Tables 1, 2, and 3.* It should be emphasized that, at this time, entries in those tables represent the writer's individual judgment and not a coordinated program position. The following assumptions underlie the numerical values shown and illustrate the methodology by which they were selected:

1. Medical experiments required to evaluate man's ability to tolerate a 28-day space flight and to extrapolate his tolerance for a 56-day flight are the most important part of the SL-1/SL-2 experiments program.

2. Within each mission, all ATM experiments are of equal operational importance and all EREP experiments are of equal importance.

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*Experiments within a given category are listed in descending order of their relative operational values. Where more than one experiment within a category is assigned the same operational value, experiments are listed in an order determined by experiment names; no priority ranking is implied among experiments having the same relative operational value.

TABLE 1. RELATIVE OPERATIONAL VALUE OF EXPERIMENTS ON THE SL-1/SL-2 MISSION

EXPERIMENT CATEGORIES	EXPERIMENTS	RELATIVE OPERATIONAL VALUE (%)	
MEDICAL	M071–MINERAL BALANCE	6	30
	M073–BIOASSAY OF BODY FLUIDS	6	
	M074–SPECIMEN MASS MEASUREMENT	6	
	M172–BODY MASS MEASUREMENT	6	
	M171–METABOLIC ACTIVITY	2	
	M092–INFLIGHT LOWER BODY NEGATIVE PRESSURE	1	
	M093–VECTOR CARDIOGRAM	1	
	M131–HUMAN VESTIBULAR FUNCTION	1	
	M151–TIME AND MOTION STUDY	1	
ATM	S052–WHITE LIGHT CORONAGRAPH	2	10
	S054–X-RAY SPECTROGRAPHIC TELESCOPE	2	
	S055–UV SCANNING POLYCHROMATOR/ SPECTROHELIOMETER	2	
	S056–X-RAY TELESCOPE	2	
	S082–UV SPECTROGRAPH/HELIOGRAPH	2	
EREP	S190–MULTISPECTRAL PHOTOGRAPHIC FACILITY	1	4
	S191–INFRARED SPECTROMETER	1	
	S192–TEN BAND MULTISPECTRAL SCANNER	1	
	S193–MICROWAVE SCATTEROMETER, ALTIMETER AND RADIOMETER	1	
OTHERS	M509–ASTRONAUT MANEUVERING EQUIPMENT	0.4	6
	M512–MATERIALS PROCESSING IN SPACE	0.4	
	S015–ZERO-G SINGLE HUMAN CELLS	0.4	
	T003–INFLIGHT AEROSOL ANALYSIS	0.4	
	T027–ATM CONTAMINATION MEASUREMENT	0.4	
	D008–RADIATION IN SPACECRAFT	0.3	
	D021–EXPANDABLE AIRLOCK TECHNOLOGY	0.3	
	D024–THERMAL CONTROL COATINGS	0.3	
	M479–ZERO GRAVITY FLAMMABILITY	0.3	
	S009–NUCLEAR EMULSION	0.3	
	S019–UV STELLAR ASTRONOMY	0.3	
	S020–UV/X-RAY SOLAR PHOTOGRAPHY	0.3	
	S063–UV AIRGLOW HORIZON PHOTOGRAPHY	0.3	
	S073–GEGENSCHEIN/ZODIACAL LIGHT	0.3	
	S149–PARTICLE COLLECTION	0.3	
	M507–GRAVITY SUBSTITUTE WORKBENCH	0.2	
	M508–EVA HARDWARE EVALUATION	0.2	
	T013–CREW VEHICLE DISTURBANCE	0.2	
	T020–FOOT CONTROLLED MANEUVERING UNIT	0.2	
	T025–CORONAGRAPH CONTAMINATION MEASUREMENT	0.2	
FLIGHT TOTAL			50

TABLE 2. RELATIVE OPERATIONAL VALUE OF EXPERIMENTS ON THE SL-3 MISSION

EXPERIMENT CATEGORIES	EXPERIMENTS	RELATIVE OPERATIONAL VALUE (%)	
MEDICAL	M071–MINERAL BALANCE	2	10
	M073–BIOASSAY OF BODY FLUIDS	2	
	M074–SPECIMEN MASS MEASUREMENT	2	
	M172–BODY MASS MEASUREMENT	2	
	M171–METABOLIC ACTIVITY	0.5	
	M092–INFLIGHT LOWER BODY NEGATIVE PRESSURE	0.4	
	M093–VECTORCARDIOGRAM	0.4	
	M131–HUMAN VESTIBULAR FUNCTION	0.4	
	M151–TIME AND MOTION STUDY	0.3	
ATM	S052–WHITE LIGHT CORONAGRAPH	2	10
	S054–X-RAY SPECTROGRAPHIC TELESCOPE	2	
	S055–UV SCANNING POLYCHROMATOR/ SPECTROHELIOMETER	2	
	S056–X-RAY TELESCOPE	2	
	S082–UV SPECTROGRAPH/HELIOGRAPH	2	
EREP	S190–MULTISPECTRAL PHOTOGRAPHIC FACILITY	1	4
	S191–INFRARED SPECTROMETER	1	
	S192–TEN BAND MULTISPECTRAL SCANNER	1	
	S193–MICROWAVE SCATTEROMETER, ALTIMETER AND RADIOMETER	1	
OTHERS	D021–EXPANDABLE AIRLOCK TECHNOLOGY	0.4	6
	D024–THERMAL CONTROL COATINGS	0.4	
	M507–GRAVITY SUBSTITUTE WORKBENCH	0.4	
	M508–EVA HARDWARE EVALUATION	0.4	
	M509–ASTRONAUT MANEUVERING EQUIPMENT	0.4	
	M512–MATERIALS PROCESSING IN SPACE	0.4	
	S009–NUCLEAR EMULSION	0.4	
	S019–UV STELLAR ASTRONOMY	0.4	
	S020–UV/X-RAY SOLAR PHOTOGRAPHY	0.4	
	S063–UV AIRGLOW HORIZON PHOTOGRAPHY	0.4	
	S073–GEGENSCHEIN/ZODIACAL LIGHT	0.4	
	S149–PARTICLE COLLECTION	0.4	
	T020–FOOT CONTROLLED MANEUVERING UNIT	0.4	
	T025–CORONAGRAPH CONTAMINATION MEASUREMENT	0.4	
	T027–ATM CONTAMINATION MEASUREMENT	0.4	
FLIGHT TOTAL			30

TABLE 3. RELATIVE OPERATIONAL VALUE OF EXPERIMENTS ON THE SL-4 MISSION

EXPERIMENT CATEGORIES	EXPERIMENTS	RELATIVE OPERATIONAL VALUE (%)	
MEDICAL	M071–MINERAL BALANCE	0.4	2
	M073–BIOASSAY OF BODY FLUIDS	0.4	
	M074–SPECIMEN MASS MEASUREMENT	0.4	
	M172–BODY MASS MEASUREMENT	0.4	
	M092–INFLIGHT LOWER BODY NEGATIVE PRESSURE	0.1	
	M093–VECTORCARDIOGRAM	0.1	
	M151–TIME AND MOTION STUDY	0.1	
	M171–METABOLIC ACTIVITY	0.1	
ATM	S052–WHITE LIGHT CORONAGRAPH	2	10
	S054–X-RAY SPECTROGRAPHIC TELESCOPE	2	
	S055–UV SCANNING POLYCHROMATOR/ SPECTROHELIOMETER	2	
	S056–X-RAY TELESCOPE	2	
	S082–UV SPECTROGRAPH/HELIOGRAPH	2	
EREP	S190–MULTISPECTRAL PHOTOGRAPHIC FACILITY	2	8
	S191–INFRARED SPECTROMETER	2	
	S192–TEN BAND MULTISPECTRAL SCANNER	2	
	S193–MICROWAVE SCATTEROMETER, ALTIMETER AND RADIOMETER	2	
OTHERS	NONE	0	0
FLIGHT TOTAL			20

3. ATM experiments as a group are of greater operational importance than the EREP. The degree of difference should be considered relatively large on the first two missions and relatively narrow on the last mission.

4. Medical experiments as a group and ATM experiments as a group should be of equal importance on the SL-3 mission.

5. On the last mission, the ATM experiment group and the earth resources experiment group are each of greater operational importance than the medical experiment group.

6. The total operational importance of all experiments on the first mission should be considered greater than the total on the second mission; the total on the second mission should be considered greater than the total on the third mission.

In addition, numerical values shown in the above-mentioned tables were selected in such a way that both they and the several category subtotals indicate only one significant figure; the criteria for selecting numerical values are simply not precise enough to warrant the appearance of more than one significant figure at this writing.

The numbers shown in Tables 1, 2 and 3 are all comparable with one another since they all represent parts of a single whole; i.e., the total operational importance of in-flight manned experiments in the Skylab I Program. To facilitate comparisons, Tables 1, 2 and 3 have been combined into Table 4* where experiment-category contributions to the Skylab I total are also shown.

4.0 Acknowledgment

Portions of the priority system described in this memorandum derive from other priority concepts discussed within ML during the past two months. The writer has also made use of ideas developed in conversations with Mr. D. A. De Graaf (MLS), Capt. C. R. Downs (MLO), Mr. D. R. Hagner (MLS), and Dr. L. N. Werner (MLA).

D. J. Belz

1025-DJB-1i

Attachments

*Experiments within a given category are listed in Table 4 in an order determined solely by experiment names; that order implies no priority ranking of any kind.

TABLE 4. RELATIVE OPERATIONAL VALUE OF EXPERIMENTS ON SKYLAB I MANNED MISSIONS

EXPERIMENT CATEGORIES	EXPERIMENTS	RELATIVE OPERATIONAL VALUE (%)						EXPERIMENT CATEGORY SUBTOTALS FOR ALL MISSIONS (%)
		EXPERIMENTS			EXPERIMENT CATEGORIES			
		SL-1/SL-2	SL-3	SL-4	SL-1/SL-2	SL-3	SL-4	
MEDICAL	M071–MINERAL BALANCE	6	2	0.4	30	10	2	42
	M073–BIOASSAY OF BODY FLUIDS	6	2	0.4				
	M074–SPECIMEN MASS MEASUREMENT	6	2	0.4				
	M092–INFLIGHT LOWER BODY NEGATIVE PRESSURE	1	0.4	0.1				
	M093–VECTOR CARDIOGRAM	1	0.4	0.1				
	M131–HUMAN VESTIBULAR FUNCTION	1	0.4	NA				
	M151–TIME AND MOTION STUDY	1	0.3	0.1				
	M171–METABOLIC ACTIVITY	2	0.5	0.1				
	M172–BODY MASS MEASUREMENT	6	2	0.4				
ATM	S052–WHITE LIGHT CORONAGRAPH	2	2	2	10	10	10	30
	S054–X-RAY SPECTROGRAPHIC TELESCOPE	2	2	2				
	S055–UV SCANNING POLYCHROMATOR/ SPECTROHELIOMETER	2	2	2				
	S056–X-RAY TELESCOPE	2	2	2				
	S082–UV SPECTROGRAPH/HELIOGRAPH	2	2	2				
EREP	S190–MULTISPECTRAL PHOTOGRAPHIC FACILITY	1	1	2	4	4	8	16
	S191–INFRARED SPECTROMETER	1	1	2				
	S192–TEN BAND MULTISPECTRAL SCANNER	1	1	2				
	S193–MICROWAVE SCATTEROMETER, ALTIMETER AND RADIOMETER	1	1	2				
OTHERS	D008–RADIATION IN SPACECRAFT	0.3	NA	NA	6	6	0	12
	D021–EXPANDABLE AIRLOCK TECHNOLOGY	0.3	0.4	NA				
	D024–THERMAL CONTROL COATINGS	0.3	0.4	NA				
	M479–ZERO GRAVITY FLAMMABILITY	0.3	NA	NA				
	M507–GRAVITY SUBSTITUTE WORKBENCH	0.2	0.4	NA				
	M508–EVA HARDWARE EVALUATION	0.2	0.4	NA				
	M509–ASTRONAUT MANEUVERING EQUIPMENT	0.4	0.4	NA				
	M512–MATERIALS PROCESSING IN SPACE	0.4	0.4	NA				
	S009–NUCLEAR EMULSION	0.3	0.4	NA				
	S015–ZERO-G SINGLE HUMAN CELLS	0.4	NA	NA				
	S019–UV STELLAR ASTRONOMY	0.3	0.4	NA				
	S020–UV/X-RAY SOLAR PHOTOGRAPHY	0.3	0.4	NA				
	S063–UV AIRGLOW HORIZON PHOTOGRAPHY	0.3	0.4	NA				
	S073–GEGENSCHEIN/ZODIACAL LIGHT	0.3	0.4	NA				
	S149–PARTICLE COLLECTION	0.3	0.4	NA				
	T003–INFLIGHT AEROSOL ANALYSIS	0.4	NA	NA				
	T013–CREW VEHICLE DISTURBANCE	0.2	NA	NA				
	T020–FOOT CONTROLLED MANEUVERING UNIT	0.2	0.4	NA				
	T025–CORONAGRAPH CONTAMINATION MEASUREMENT	0.2	0.4	NA				
	T027–ATM CONTAMINATION MEASUREMENT	0.4	0.4	NA				
FLIGHT TOTALS					50	30	20	SKYLAB I TOTAL ≡ 100%

NOTE: NA ≡ NOT ASSIGNED TO THIS MISSION.

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From: D. J. Belz

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